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DELTA AND DESERT VEGETATION.

DANIEL TREMBLY MACDOUGAL.

(WITH SEVEN FIGURES)

THE systematized discussion of the deserts of North America recently attempted by Mr. Coville and the author[1] made it obvious that the southern extension of the Nevadan-Sonoran desert in Sonora and peninsular California around the head of the Gulf was practically a *terra incognita* to the naturalist.

The waters of the Gulf have been surveyed and the more prominent features of the shore lines traced, but since this work was done thirty years ago, the charts, originally made from data collected by "Commander" George Dewey in 1873–75, are sadly in need of revision, especially in the region contiguous to the mouth of the Rio Colorado. The positions of the prominent hills and mountains visible from the sea have been plotted as range marks for the navigator, but the maps bearing the results are difficult of interpretation by the explorer on land.

A fair share of attention has been paid to the animal life of the river and Gulf, but the extensive areas around the mouth of the river and the head of the Gulf have so far practically escaped investigation. These regions offer difficult problems of transportation and subsistence to the explorer. The southern part of the delta includes vast areas of muddy salt flats cut by a labyrinth of shallow pools and channels, and joining directly the desert slopes and plains of Baja California and Sonora. The water in the lower course of the river is brackish for a distance of 30^{km} from the sea, while other sources of water are uncertain and widely separated, the tropical sun forming an additional factor to test the endurance of the unaccustomed traveler. In running the boundary on the long northwestward slant of the Arizona-Sonoran line after the Gadsden Purchase Treaty, the commission found it necessary to haul water nearly 200^{km} to meet the needs of its camps. The trail which runs near the boundary across a typical portion of the desert mesa was the route followed by Mexican prospectors rushing to the Californian gold fields in 1849, and in the waterless stretch of 150^{km} between Quitovaquito and Tinajas Altas may be counted over four hundred small circles and crosses of loose stones by the side of the trail, grim evidences of failures to negotiate this formidable "Jornada del Muerto."

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[1] COVILLE, F. V. and MACDOUGAL, D. T., The Desert Botanical Laboratory of the Carnegie Institution. November, 1903. Washington, D. C.

Attempts to penetrate the desert directly from the coast have met with equally serious difficulties. The shore is fringed with mud flats many kilometers in width, and numerous sand bars bare at low water; the tides rise $4–10^{m}$ and produce currents that run $4–8^{km}$ per hour, forming waves or bores that sweep up the river, at times endangering all craft not in protected anchorages. But few sheltered anchorages are to be found in the upper Gulf, and nearly all of these are far from a supply of fresh water. The few expeditions to this region in which attention was paid to the flora are easily recounted.

Colonel Andrew B. Gray traversed the desert from the international boundary to Adair Bay in 1854, discovering the singular parasitic *Ammobroma Sonorae* Torr.,[2] which fastens to the roots of Franseria and Dalea at depths of $60–120^{cm}$ in the sand, and sends its fleshy stems to the surface, on which the flowers appear to rest.

Dr. E. Palmer traveled southward from Yuma to Lerdo near the head of tidewater in 1889, and collected about two dozen species of plants,[3] but no general account of the expedition is available.

Descriptions of a number of the plants are to be found in the accounts of the boundary survey,[4] in which but little attention, however, appears to have been paid to the flora of the delta.

T. S. Brandegee[5] made a long journey overland, in the same year in which he traversed Baja California, for a distance of several hundred miles northward to San Quintin in about the same latitude as the southernmost point reached by my own expedition. However, he did not reach the country east of the main divide north of San Luis Bay, 300^{km} south of the mouth of the river.

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[2] Torrey, J., Ammobroma, a new genus of plants. Ann. Lyc. Nat. Hist. N. Y. **8**: June 1864.

[3] Rose, J. N., Contrib. U. S. Nat. Herb. **1**:27. 1890.

[4] Report on U. S. and Mex. Boundary Survey, Emory **2**:21. 1859.

[5] Brandegee, T. S., A collection of plants from Baja California, 1889. Proc. Calif. Acad. II. **2**:—. 1889.

Mr. Edmund Heller made some explorations and zoological collections for the Field Columbian Museum, February–December 1902, in which the western slopes of the Santa Catalina, San Pedro Martir, or Calamuie Mountains and of the Hanson Laguna Mountains were traversed. Mr. Heller crossed the main divide in about latitude 31° 30′, south of the main elevation of Calamahuie, to Parral, which lies about 600^{m} above sea level. One degree to the northward the main range was again crossed at San Matias Pass and his expedition reached the bay of San Felipe. The account of this work contains notes on the occurrence of many important plants, including the giant cactus and the Washington palm.[6]

The author organized an expedition to this region early in the present year, under the joint auspices of the Desert Botanical Laboratory of the Carnegie Institution, and of the New York Botanical Garden. In accordance with plans made a year previously, Mr. G. Sykes, civil engineer, of Flagstaff, Arizona, proceeded to Yuma in November 1903, where the construction of a small sloop, 9^{m} in length with 2.4^{m} beam, was begun and which was brought to completion late in January 1904. This boat was of a flat-bottomed design suitable for floating down the muddy shallows of the river, and was furnished with a centerboard for use in sailing the rougher waters of the Gulf, being rigged with a mainsail and jib.

In addition to the camp equipment, which included means for storing and carrying fresh water, and a special form of portable canteen, provisions, compasses, binoculars, cameras, aneroids, thermometers, hygrometers, and other material to a total weight of about 500^{kg} was taken aboard. The party included Prof. R. H. Forbes, Director of the Agricultural Experiment Stations of Arizona, and an assistant, in addition to Mr. Sykes and the author. A general narrative in which the detailed movements of the expedition are given has already been published[7] and need not receive further attention in this article.

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[6] ELLIOT, D. G., A list of mammals collected by Edmund Heller in the San Pedro Martir and Hanson Laguna Mountains and the accompanying coast regions of Lower California. Field Columbian Museum, Publ. 79 Zoological Series 3: no. 12. 1903.

[7] MACDOUGAL, D. T., Botanical explorations in the southwest. Jour. N. Y. Bot. Garden 5:89. 1904.

THE DELTA.

The expedition cast loose from the shore at Yuma at noon on January 28, and within a short distance below the sand bluffs on either hand curved away from the stream, and we were fairly in the great delta which extends from this point to the Gulf of California, a distance of about 140^{km}; while the coastal plains on the western side of the Gulf embrace mud flats that constitute an actual extension of the delta 50^{km} further. This delta probably offers more varied and striking features of natural history than any other watercourse in North America. The river which has formed it rises in the perpetual snows of Utah, Wyoming, and Colorado, and runs 2500^{km}, chiefly through arid regions, before it empties into the upper end of the subtropical Gulf, into which it carries sixty million tons of sediment yearly, building up the delta and extending it seaward at a rate visible to common observation within a single lifetime.[8] Numerous witnesses among the Cocopa Indians, Mexicans, and river men are agreed that the various distinct associations of plants characterized by salt grass, willow, and poplar, have advanced about $12–14^{km}$ to the southward during the last fifty years.

The portion of the delta near the present course of the river consists of an alluvial plain, not more than 4^{m} above the low-water mark, subject to constant bank erosion, shifting, and remaking of the soil, cut in all directions by old channels existing as bayous and sloughs, and flooded at high water in May, June, and July. Almost pure formations of willow and poplar (*Populus mexicana*) cover many square kilometers and furnish food for thousands of beavers that burrow in the banks. The poplar is thickly infested with a mistletoe (Phoradendron), and fungal parasites are abundant. Large areas are occupied by the arrow-weed (*Pluchea sericea*), and mesquite (*Prosopis velutinea*), and the screw-bean or "tornilla" (*P. pubescens*). Two or three species of Atriplex are also to be found in sections in which the action of the water prevents the establishment of the woody perennials of greater size. In the upper part of the delta a cane (Phragmites) fringes the channel, and its closely interwoven roots act materially in preventing erosion of the banks.

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[8] FORBES, R. H., The Colorado river of the west. Univ. of Ariz. Monthly **6**:112. 1904.

In the lower part of the delta, where the river is affected by the spring tides, the cane is partly replaced by a cat-tail "tule" (*Typha angustifolia*), which not only lines the shores for many miles, but extends back some distance on areas free from trees, forming dense masses that afford shelter for a number of animals, including a peculiar subspecies of a small mountain lion.

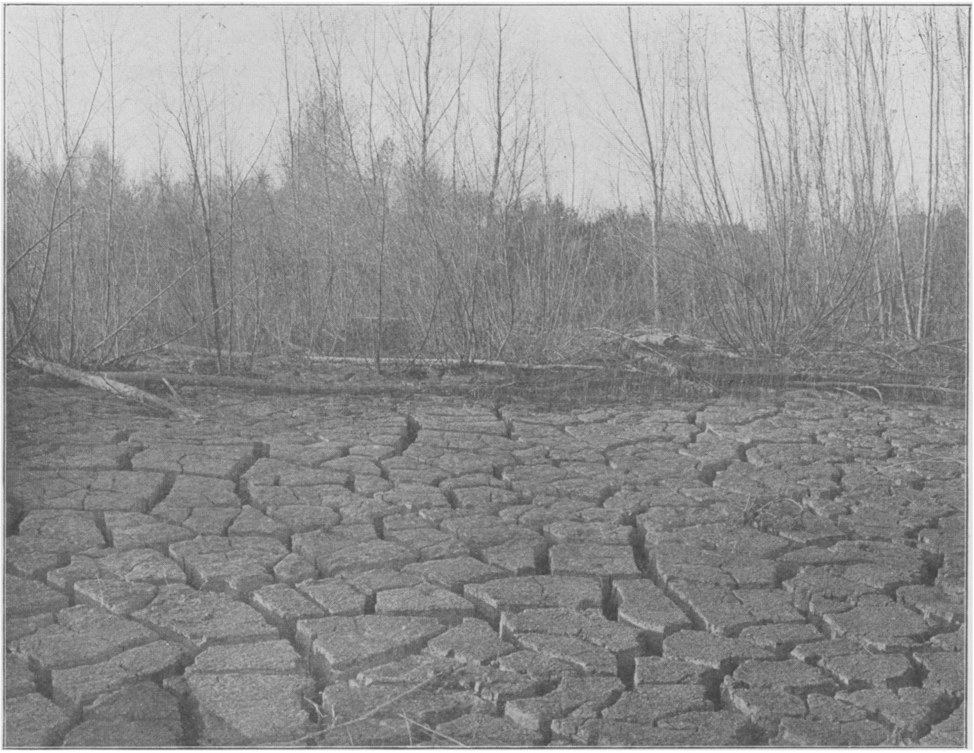

FIG. 1.—Scene on right bank of Rio Colorado, Baja California, a few meters from the margin of the stream, 10^{km} below Yuma; the conchoidal fractures of the clayey mud are 30–35^{cm} in depth; Salix and Populus in background; Station 1 of hygrometric observations.

Large areas throughout the delta which were not covered by trees bore wild hemp (Cassia ?) in great abundance. The slender stems reach a height of 3–4^{m}, branch profusely above, and bear numerous pods. At the time of our visit, the plants which were annuals were dead and dry, still retaining the seed pods, and progress through one of these plantations was accompanied by a shower of seeds which results from any disturbance of the plant. The clearings also furnished suitable conditions for a plant with a deeply buried bulb, probably a Calochortus, which is eaten by the Cocopa Indians under the name of "chech," and also forms an important article of food of the sand-hill crane, and of the wild hogs that infest the tules.

The forests of willow and poplar begin to lose density at a distance of 50–60^{km} from the Gulf, the willows extending farthest toward salt water, a few being seen near the mouth of the Hardy branch of the Colorado. Beyond these are the mud plains, the portions not actually subject to erosion being thickly covered with salt grass (*Distichlis spicata*) and *Cressa truxillensis*, and bearing small clumps and isolated specimens of salt bush (Atriplex), mesquite, and screw bean. Such areas are inundated at the highest tides; consequently the soil solutions are heavily charged with salts, and whitish alkaline crusts appear during the winter dry season.

The floods of spring and early summer from the rains and melting snows of the headwaters region of the river raise the level of the water until it flushes the innumerable old channels and covers the greater part of the delta. Most of the herbaceous species make their annual growth after the waters have subsided in July. Other species, which are less affected by the lower temperatures and low relative humidity of the winter season, are set in action by the favorable conditions of March and April, and come into bloom at this time, thus making two distinct seasonal groups of annuals.

The main stream of the river cuts directly into the gravel plain or mesa of Sonora at four points on the eastern margin of the delta, and here are to be seen the striking contrasts of the isolated xerophilous plants of the dry gravelly soil of the desert within a few meters of the pure dense formations of the muddy soil of the alluvial plain of the delta (*fig. 2*). In places the creosote bush (Covillea) descends the gentler slopes to the margin of the moister soil near the margin of the channel, accomplishing a growth which carries it to a height of over 7^{m}, the maximum size for the species.

The above description applies most directly to the eastern and southern portions of the delta, which may be observed in the descent of the river, but it by no means exhausts the interesting features of the region. If the low-lying contiguous areas to the westward capable of being flooded are included, the delta may be said to have an area approximately equal to the state of Connecticut. One arm extends over 200^{km} to the northwestward and includes the Salton Basin, with its exposed bottom more than 130^{m} below the level of the sea. Although the summer floods of extreme height find their way by old channels into this basin, creating a temporary lake of great extent, yet the district affected must be classed as desert, since the highly saline character of the soil and prevailing low humidity and precipitation support representative types of vegetation (*fig. 4*).[9] Other basins ordinarily dry, with saline deposits, are to be found in various parts of the depressed area, which has the characteristics of a sea-floor of comparatively recent date.

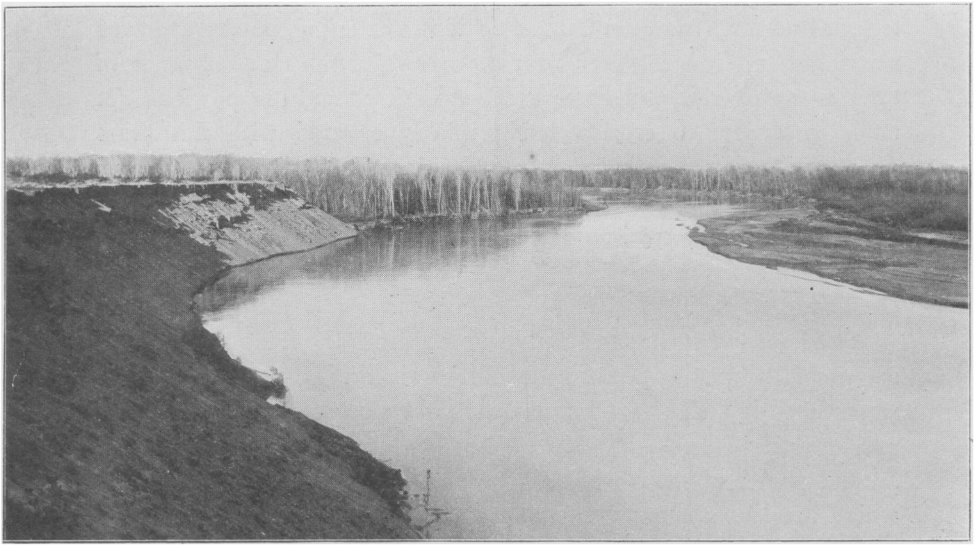

FIG. 2.—View of Rio Colorado at a point where it cuts into the desert mesa of Sonora a few kilometers south of international boundary; looking downstream; Populus and Salix on right bank; dense forest of Populus in background on left bank; portion of mesa in foreground on left bank with Covillea, Stillingia, and Ephedra; Station 3.

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[9] See also COVILLE and MACDOUGAL, The Desert Botanical Laboratory of the Carnegie Institution (November 1903), pp. 21–22. *pls. 23–26.*

Many parts of the delta and of the adjoining districts in the deserts of Sonora and Baja California show traces of recent earthquakes and of volcanic action, a tract 2 by 10^{km} being now occupied by a number of active mud volcanoes.

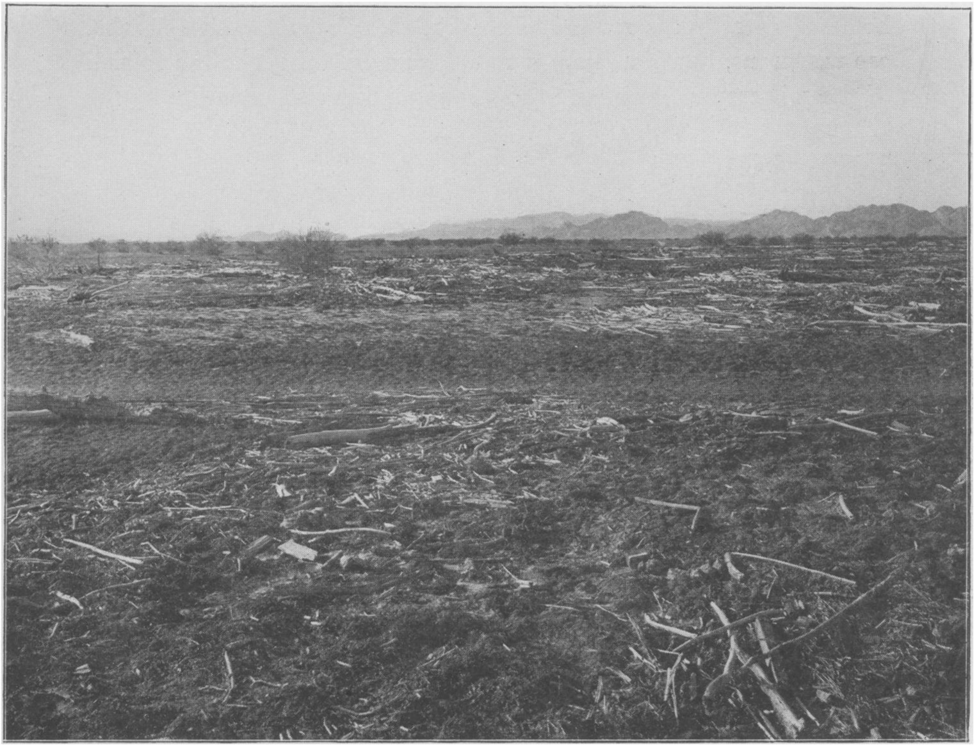

FIG. 3.—View to southward on floodplain of Rio Colorado below mouth of Hardy's branch; Range Hill in distance; carpet of *Cressa truxillensis* and *Distichlis spicata;* Prosopis scattered over plain, which also shows great quantities of driftwood.

The Cocopa Mountains rise directly from the delta to a height of over 1300^{m}, and their granite slopes support an island of desert vegetation of the types induced by low humidity and precipitation.

DESERTS.

The arid region east of the delta, extending southward from the Gila River, consists principally of long gentle slopes or sandy gravelly plains rising gradually toward the interior, and broken here and there by a succession of low mountain ranges, such as the Agua Dulce, Pinacate, and Santa Clara Mountains. The soil is particularly subject to the action of the wind, but the irregular consistency of the sand allows the formation of moving dunes or "sables" in a few localities only near the delta. Mounds of a few meters in height, held together by the roots of Ephedra, Covillea, and other shrubs, are numerous, however, such mounds being due either to the erosion of the soil around them, or to its accumulation and retention by the clumps of plants. In addition to the few herbaceous annuals which arise during the season favorable for growth, the principal types are perennials with spinose branches and reduced deciduous leaves, although a few species with hardy leaves are included. *Ephedra*, *Gaertneria albicaulis*, *Oenothera claviformis*, *Lupinus mexicana*, *Abronia villosa*, *Astragalus Vaseyi*, *Plantago scariosa*, *Langloisia Schottii*, *Stillingia annua*, *Asclepias subulata*, and *Fouquieria splendens* are typical examples; while a few forms with deeply lying bulbs are also found here, including *Hesperocallis montana* (*fig.* 5).

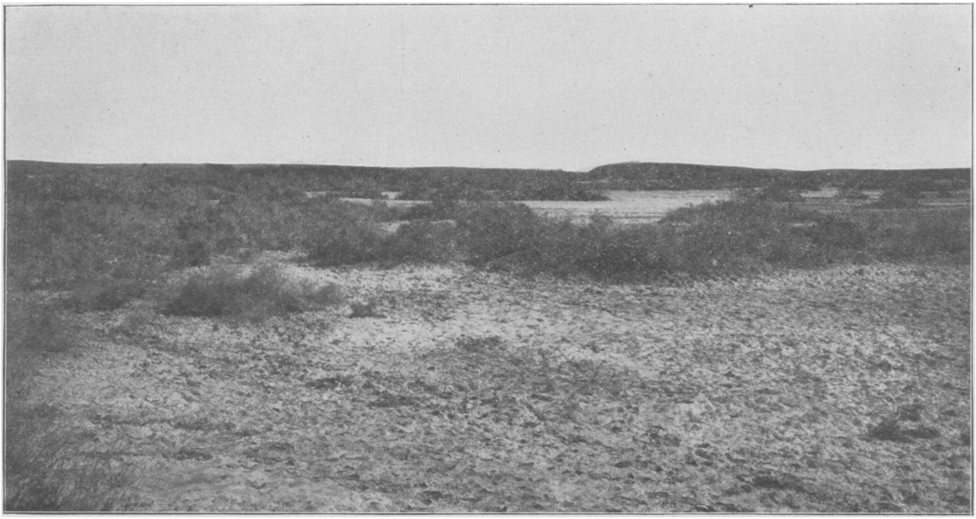

FIG. 4.—View in Salton Basin, California; the surface of the soil is thickly incrusted with saline matter in the open spaces; the vegetation consists chiefly of Spirostachys and Atriplex.

The character of the portion of the Colorado desert lying within the state of California is the subject of a recent paper by S. B. Parish,[10] and need not be discussed further here. He says, concerning the delta: "the region bordering the Colorado River is too little known to permit exact statements regarding it."

The arid region of Baja California to the eastward of the main divide covers an area of much greater topographical diversity, but with less rainfall probably than the Sonoran slopes across the Gulf, from which its flora is widely different in general composition. My examination of this part of the country was made from San Felipe Bay, which lies about 60^{km} south of the mouth of the Rio Colorado in latitude 31° N. The western shore of the Gulf between this point and the river is made up of a continuation of the mud-flats of the delta, and has great expanses covered with Cressa and salt grass.

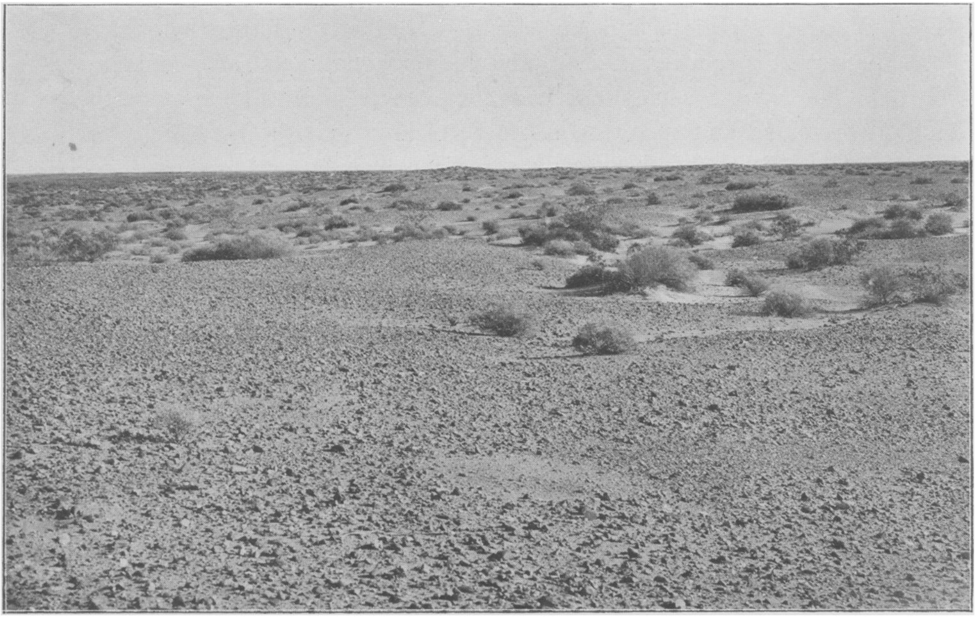

FIG. 5.—View to southeastward from Lerdo, Sonora; the gravel mesa bears scattering bushes of Covillea and Ephedra.

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[10] PARISH, S. B., A sketch of the flora of Southern California. BOT. GAZ. **36**: 203–222, 259–279. 1903.

The central elevation consists of the mountain ridge which culminates in the peak of Calamahuie at an elevation estimated at about 3300^m. To the eastward it breaks into lofty precipices and steep slopes which have not been surmounted between 30° 30′ and 32° 30′ N., no passes having been found in this wild stretch of 100^{km}. Between the main range and the coast lie numerous minor ranges disposed in labyrinthine complexity, which also have not been explored. So far as available information may be relied upon, no botanist had previously visited this region, and some care was taken to secure living and preserved specimens of the native plants whenever at all possible.

The lower coastal slopes were found to be sandy and gravelly, the depressions and near the shore furnishing suitable conditions for *Lycium Torreyi* and *Parosela spinosa*, which latter becomes a tree 7^m in height. *Asclepias subulata* was abundant in clumps, and *Ditaxis serrata* grew on level areas. Other species, characteristic of the lower levels, were *Ibervillea tonella*, *Croton californicum*, *Lupinus mexicanus*, and the curious *Frankenia Palmeri*. The low alkaline pockets reached by the spring tides furnished conditions suitable for *Spirostachys occidentalis*. Covillea, with its enormous capacity of adjustment, extended from near the shore across the entire slope and up the granite mountains through a range of over 600^m in elevation. The various portions of the slope between the sea and the first range of mountains supported ocotillo (*Fouquieria splendens*), which attained its maximum height of 10^m, palo verde (*Parkinsonia microphylla*), palo fierro (*Olneya tesota*), Bursera, and *Gaertneria ilicifolia*. The streamways leading down from the mountains were inhabited by a number of Eriogonums and euphorbiaceous herbs. A few Opuntias of the cylindrical arboreous type, an Echinocactus, a Mammillaria, and a small Cereus were also seen. *Pilocereus Schottii*, which is found on the mainland far southward, here reaches the greatest density yet observed, forming dense forests, acres in extent. Perhaps the most notable feature from a geographical point of view was shown by the presence of a great tree cactus, having the appearance of *Cereus pecten-aboriginis*. *Cereus Pringlei* is known to be abundant under the common name of "cardon" farther south, but this plant appears to agree with the former, and makes a splendid picture in the arid landscape, finding here its extreme northern limit of known occurrence.

The large number of species with laticiferous juices was especially noticeable, but with the exception of the dozen Cacti no plants with organs for the storage of water were seen, a fact possibly connected with the extremely low precipitation and low water content of the soil at all times. Seeds of a Cenchrus were very abundant and were used by burrowing rodents as a means of fortification of the entrances to their burrows, in the same manner that the joints of the "cholla" are employed elsewhere.

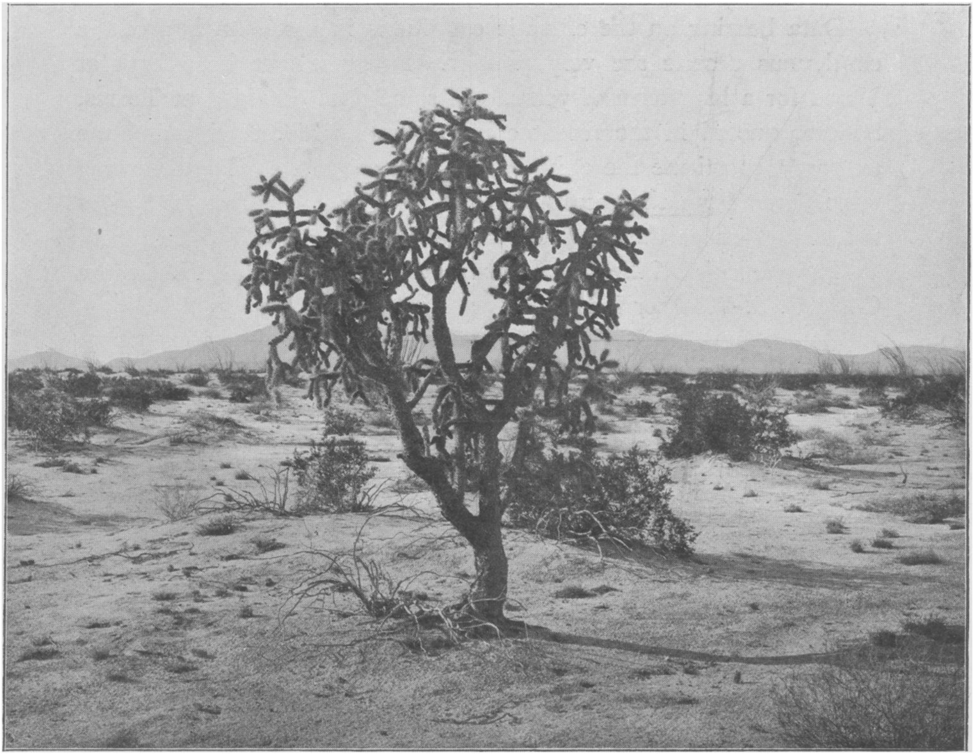

FIG. 6.—Desert of Baja California, looking westward from beach north of San Felipe Bay; Opuntia, Covillea, and Fouquiera.

A mountain to the southwestward of San Felipe Bay was climbed and a summit reached at an elevation of over 1000^{m}. The granite slopes supported a sparse vegetation of such types as Mammillaria, Ephedra, *Bursera microphylla*, *Asclepias albicans*, *Eriogonum infla-*

tum, Yucca, Agave, and Opuntia. So far as might be estimated by the instruments at hand, the mountain is probably the one on the hydrographic map of 1873–75 designated as a "sharp white peak 4288^{ft}," which had not previously been ascended, and still bears no name.

METEOROLOGICAL FEATURES.

Data bearing on the climatic conditions in the delta and of the contiguous deserts are very meager. Records have been kept at Yuma for a long term of years, and some data obtained at Torres, Sonora, quoted in the recent contribution by Mr. Coville and the author,[11] constitute the only information available. The following table taken from the records of the U. S. Weather Bureau[12] gives the conditions at the head of the delta.

The transcript of the record was furnished by Hon. Willis L. Moore Chief U. S. Weather Bureau.

1903	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total	Normal
Maximum temperature	76	82	90	97	106	112	111	113	112	96	87	80	..	..
Minimum temperature	33	29	38	47	50	60	69	72	59	51	42	34	..	..
Precipitation	..	.23	..	..	..	..	.04	..	.67	.04	..	..	.98	2.98
Average precipitation (1876–90)	.39	.45	.18	.12	.06	..	.13	.40	.13	.21	.35	.64	3.06	..

MEAN RELATIVE HUMIDITY.

8 A. M.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1903	53.5	62.9	53.3	52.0	61.3	59.9	61.1	68.3	67.4	54.3	46.7	39.5
1904	43.0	45.7	....	....	....	....	....	....	....	....	....	....

8 P. M.

1903	28.0	44.8	23.0	17.0	17.9	17.8	21.7	2.82	30.9	23.7	28.4	24.2
1904	20.7	21.7	....	....	....	....	....	....	....	....	....	....

It is to be seen that the delta and the contiguous districts have an annual precipitation of less than 7^{cm}, and that less than 2^{cm} was received during the year 1903, the relative humidity at all times being very low also. The rainfall is distributed throughout the year, so that only a small proportion of the total is received within any month; furthermore, this distribution is irregular in any series of seasons, so that the native plants have but little opportunity of acquiring a rhythm of activity in response to the annual supply of moisture, a fact not without its influence on the general anatomical character of the plants, as will be pointed out below. In no part of the country to the southward of Yuma did we find any evidences of a greater rainfall than that given above, upon noting the surface of the soil

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[11] Desert Botanical Laboratory of the Carnegie Institution, p. 23. November 1903.

[12] Greely and Glasford, Report on the climate of Arizona. Ex. Doc. No. 287. Washington. 1891. Climate and Crop service, U. S. Weather Bureau. Report for Arizona Section for 1903.

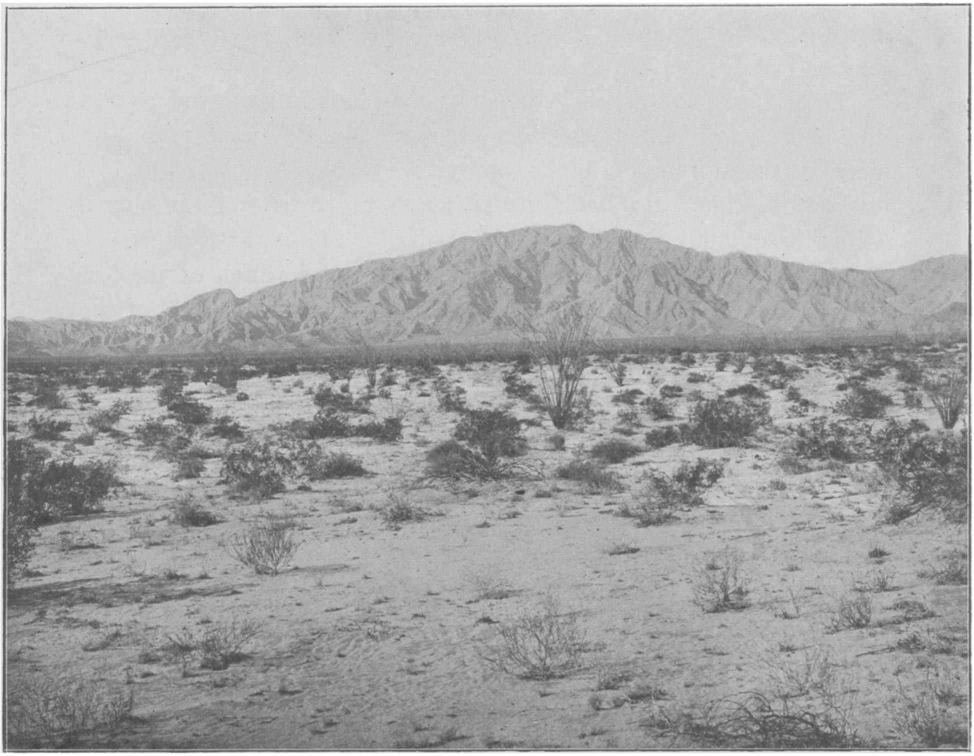

FIG. 7.—Desert of Baja California; view from San Felipe Bay; peak over 1000^m high, ascended February 14, 1904, in distance; the sloping plain which rises gradually to the foot of the mountain bears Fouquieria, Ephedra, Covillea, Bursera, Parosela, Parkinsonia, and Cereus.

and the state of resting vegetation, and no precipitation occurred during the month the expedition was actually in field. Attention is to be called to the table of relative humidity, in which it is to be seen that the minima are very low, yielding averages from 17 to 30 per cent. So far as a general inspection could be relied upon, it did not appear that precipitation had occurred at San Felipe Bay within three months, and it might well have been three times that period since any had been received.

Dr. Edward Palmer visited the Raza Islands in the lower part of the Gulf, 225^{km} northwest from Guaymas, in February 1890, and notes that no rainfall had been received there for more than a year.[13] Nothing can be hazarded as to the extent of the region with this extreme limit of aridity on the Sonoran side of the Gulf, except that it does not include the mesa at an elevation of 300^{m} at Torres, and it does not appear to include the western slope of the central range in Baja California, although no definite information is available. So far as known at the present time, therefore, this region of extreme and constant drought, constituting the most pronounced type of desert in North America, lies on the eastward or lee side of the San Pedro Martir range of Baja California, and includes areas on the Sonoran mainland, the whole being a southern extension of the Colorado desert. It is evident, however, that a further investigation of the region is necessary to determine the exact meteorological status of this area, as well as the general character, derivation and relationships of its flora. The extreme type of strict desert offered by the area in question points to the possibility of finding here the readiest solution of some of the more important problems presented by desert vegetation.

RELATIVE HUMIDITY IN DELTA AND DESERT.

The relatively brief time during which the expedition was in the field made it impossible to secure records of value as to precipitation, although it has been noted above that no rainfall occurred, except perhaps on the higher peaks of the Cocopa Mountains and of the main range in Baja California. A Lamprecht's hair hygrometer was carried, however, and observations were taken daily, the instrument being compared before being taken into the field and after its return with other instruments for standardization. The data given below are corrected results, not direct transcripts from the notebook.

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[13] Contrib. U. S. Nat. Herb. 1:79. 1890.

Station 1.

Camp on dried mud flats on shore of Rio Colorado a kilometer below international boundary in Baja California; observations taken twenty feet from margin of bank amid willows and poplars; wind blowing offshore; see *fig. 1*.

Jan. 28	4:30 P. M.	60° F.	17% rel. hum.
“ 28	6:30 “	55 “	15 “
“ 28	8:00 “	51 “	18 “
“ 29	12:45 A. M.	32 “	41 “
“ 29	1:20 “	30 “	50 “
“ 29	6:00 “	29 “	66 “
“ 29	6:25 “	27 “	70 “
“ 29	7:00 “	38 “	60 “
“ 29	7:40	Sun on instrument	36 “

Station 2.

Camp on small island in great bend 33^{km} downstream from Yuma, covered with a dense grove of Salix except at one end.

Jan. 29	4:50 P.M .	61° F.	21% rel. hum.
“ 29	7:10 “	37 “	75 “
“ 29	8:45 “	32 “	57 “
“ 30	2:45 A. M.	30 “	84 “
“ 30	5:45 “	26 “	58 “
“ 30	7:50	Sun on instrument	35 “

Station 3.

Camp at lower end of high mesa bank below La Grulla, Sonora; observations taken at a point 60^{m} from margin of bank 13^{m} in height, constituting bank of river, among bushes of Covillea, Ephedra, etc. (*fig. 2*).

Jan. 30	4:40 P. M.	70° F.	19% rel hum.
“ 30	4:50 “	68 “	16 “
“ 30	7:00 “	54 “	15 “
“ 30	8:30 “	48 “	27 “
“ 31	6:30 A. M.	44 “	30 “
“ 31	7:30 “	45 “	29 “

Station 4.

Noon stop made at point where the river cuts into the Sonora mesa above "Noche Buena" cut-off; observations made at a point corresponding to Station 3, with similar vegetation.

Jan. 31	1:45 P. M.	72° F.	15% rel. hum.

Station 5.

Camp on dry shore in Baja California among willows, poplar, and saltbush, with numerous beaver slides along bank.

Feb. 1	7:00 P. M.	50° F.	30% rel hum.
" 1	8:30 "	44 "	66 "
" 2	6:30 A. M.	41 "	59 "

Station 6.

Group of adobe buildings at Colonia Lerdo, on margin of gravel mesa sloping gradually to the delta, 2^{km} from stream, among mesquite, saltbush, and arrow-weed.

Feb. 3	11:40 A. M.	78° F.	16% rel hum.
" 3	1:30 P. M.	81 "	11 "
" 3	4:15 "	79 "	10.5 "

Station 7.

Camp on eastern shore of river at Colonia Lerdo, among poplar, willow, cane, and tule, 25^m from margin of water and 2^m above surface.

Feb. 5	7:25 P. M.	64° F.	38% rel. hum.
" 5	7:45 "	64 "	40 "
" 5	2:10 "	67 "	37 "

Station 8.

The data given below were obtained at a number of points on the plain and mountains, near camp on San Felipe Bay, Baja California.

Tent on beach.

Feb. 11	6:20 P. M.	52° F.	42% rel. hum.
" 11	8:20 "	49 "	39 "
" 12	5:50 A. M.	37 "	44 "
" 12	8:00 "	56 "	27 "
" 12	8:35 "	63 "	24 "

In shade of Bursera.

At 76^{m} level, 13^{km} from shore.

Feb. 13	1:00 P. M.	71° F.	40% rel. hum.
“ 13	6:15 “	57 “	41 “
“ 14	6:00 A. M.	60 “	33 “

800^{m} on mountain.

Feb. 14	8:45 A. M.	69° F.	32% rel. hum.

1200^{m} on mountain (*fig. 7*).

Feb. 14	11:00 A. M.	72° F.	32% rel. hum.

Small mountain 100^{m} high, 20^{km} north.

San Felipe, 8^{km} from coast.

Feb. 19	9:45 A. M.	72° F.	18% rel. hum.

RÉSUMÉ.

It is to be seen that the region discussed in the foregoing paper includes a subtropical delta of irregular outline and long extensions, which includes within its outermost boundaries a great alluvial plain object to floods, bank erosion, and shifting of the soil, and also to the action of salt tidal waters; a mountain range of granite and volcanic rocks over 1000^{m} in height; a small area of active mud volcanoes; a depressed region, presumably an old sea-floor, the bottom of which is more than 100^{m} below the level of the sea; and the mud flats near the actual mouth of the river. This delta is directly in contact with the gravel and sand desert mesas of Sonora and Baja California.

The portion of the delta subject to the direct action of the floods and tides is everywhere slightly alkaline and varies but little in the general constituency of the soil, supporting a luxuriant growth of vegetation, the more important elements of which grow in pure formations of the greatest possible density. The larger woody plants of this region have their bases submerged in water at a low temperature during the summer season, during which time the crowns are exposed to low relative humidity at temperatures that may be as much as 70° F. higher than the roots. In consequence of this condition many species in the low lands have xerophilous foliage. In addition, a comparatively high concentration of soil salts must be endured during the stages of low water.

An analysis of the flora of the region shows that many of the species of the delta extend down along the coast especially in the regions with fringing mud banks derived from the river deposits. The greater part of the vegetation of the coastal slopes and plains, however, is made up of species which also extend southward along the shores of the Gulf, and are found but sparingly to the northward.

The vegetation of the Salton basin is subjected to the action of extreme aridity and also of a high concentration of soil salts, comprising types of the most pronounced character, both of halophytes and xerophytes. The elevations included in the delta are dry mountain slopes and support a desert vegetation.

The mesas adjoining the northern part of the Gulf of California appear to offer the most extreme desert conditions in North America. The rainfall at Yuma at the northern extremity of the delta was less than 25^{mm} during 1903, and years have been noted at points farther south in which no precipitation occurred. The entire normal precipitation in the desert in Baja California is probably no greater than the amount of water condensed as dew in eastern United States. The desert apparently extends to the slopes of the central elevation of the peninsula to the westward, which reaches an elevation of over 3000^{m}. This mountain wall probably acts as a barrier which shuts off moisture-laden winds from the Pacific and causes the aridity of the region. The southern and eastern limits of the extreme desert cannot be defined with the information now at hand.

The vegetation of the desert areas in the regions of greatest aridity consists chiefly of types devoid of massive storage organs, and of perennials with laticiferous sap, while a large number of forms secrete volatile oils or exude resinous gums. The determination of the causal relations of these adaptations cannot be made safely by a general interpretation of the aspects of vegetation, but it is to be seen that in a region in which surplus rainfall or ground water never occurs, storage organs would be manifestly useless, and indeed their formation impossible. Species with spinose branches and minute leaves which are quickly discarded during unfavorable periods are abundant. Several species of Ephedra with functionally useless leaves and chlorophyllose stems are included, while Lycium and Frankenia with small succulent easily detachable leaves are highly characteristic of some localities; the last-named species are about the only species offering anything of the nature of water-storage organs outside of the Cacti.[14]

The region under discussion offers matchless opportunities for comparison of the most highly developed xerophytic types of the desert with the broad-leaved forms of the delta which root in the mud. Midway between the two are the species which stand in the moist soil of the delta, and have foliage suitable to endure the extreme aridity of the air, which constantly blows from the desert over the entire delta.

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[14] MACDOUGAL, D. T., Some aspects of desert vegetation. Plant World **6**:249–257. 1903.